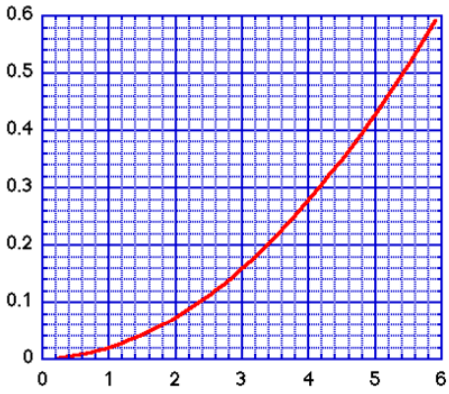
# Contents






## 1.0 Purpose/Scope

This procedure provides standardized methods of calibration for meters such as the *Scott Scout*® Multi-Gas Monitor, Miran Sapphire, Gportable Gas Chromatograph, TVA-1000, etc.. It provides a standardized procedure for conducting & recording meter calibration for monitors used for confined space and other direct reading atmosphere testing. This SOP is limited in scope to use only by SHSD Industrial Hygiene personnel. It is limited in scope only to calibration of vapor or gas chemical monitors. It does not cover calibration of particulate samplers, non-ionizing radiation monitors, noise monitors, XRF, etc.

## 2.0 Responsibilities

Personnel that perform calibration are responsible to:

- Demonstrate competency to perform calibrations as evidenced by experience and training to the satisfaction of their supervision's qualification criteria.
- Follow all steps in this procedure and the meter's manufacturer's operating manual instruction on meter calibration..

## 3.0 Definitions none

## 4.0 Prerequisites

4.1 **Area Access:** Calibrations involving hazardous gases/vapors are to be done in the lab hood in Building 120, Room 1-19. No area access qualification is necessary other than OSHA Laboratory Standard (HP-IND-220) and TQ-OSH-157 *Personal Protective Equipment.*

4.2 **Qualification:** The use of this procedure is limited to persons who have demonstrated competency as determined by Section 7 of this procedure. The person conducting calibration on a particular brand of meter must be proficient in the operation of that meter by IH Group SOP and be knowledge able of operation and calibration as per the manufacturer's Operation Manual.

## 5.0 Precautions

**5.1 Hazard Determination:**

- The calibration of monitor/meters does not cause exposure to radiological hazards.
- Calibrations do not cause significant ergonomic concerns.
- Calibrations can cause physical hazard exposure from compressed gas cylinders.
- Calibrations can generate environmental emissions, but not hazardous waste. IH50900 documents the environmental impact of calibration operations. Calibration gases are to be vented from Building 120 via the lab hood exhaust stack in Room 1-19.
- Calibrations may involve use of hazardous gases. Inhalation of toxic gases or oxygen deficient atmospheres can have significant health consequences. Some calibration gases may be flammable. A hazard evaluation by a cognizant ESH professional has resulted in the requirement to conduct calibration within the laboratory hood. This control measure prevents significant worker exposure.

**5.2 Personal Protective Equipment (PPE):** Calibration of meters typically does not require PPE except Safety Glasses with side shields for protection from compressed gas hazards.

In addition, work with gas cylinders in a hood with an acrylic sash is required.

## 6.0 Procedure

6.1 **Equipment:**

- Meter & Sample Probe
- Calibration gas or vapor, generated by either:
  - Cylinder of NIST traceable gas of known concentration;
  - Static bag mixture of vapor/gas (Tedlar Bag, microliter gas tight syringe, 10 L gas syringe or calibrated air pump; or
  - Closed loop system, (re-circulating air pump, microliter gas tight syringe, appropriate tubing and connectors to meter)

6.2. Refer to Attachment 9.4 for methods of creating known concentrations of gases or vapors if a calibration gas cylinder is not used.

6.3. Turn the meter on as per the meter's instruction manual or meter's IH SOP. Allow the meter to warm up for the period specified in the manual or SOP.

6.4. Within the hood, attach the meter probe to the calibration gas cylinder or source of calibration gas/vapor.

6.5. Turn on the flow of calibration gas cylinder or start the source.

6.6. Observe the meters readout and record readings for the sensor(s) during calibration using Attachment 9.2 (Multiple Gas Meter Calibration & Maintenance Record) or Attachment 9.3 (Multi-point Calibration Record). These become official records and are to be secured in the calibration record files maintained by the IH group as per IH60200.

- **Alarms:** The alarm points on multiple gas meters should be verified during calibration of the instrument. Record on the calibration record if the meter fails to alarm when exposed to gas at the alarm concentration.

7.0 **Implementation and Training** Prior to using this SOP to perform calibrations:

7.1 Demonstrates proper operation of the meters to be calibrated
7.2 Demonstrate knowledge of the appropriate calibration method from Attachment 9.4.
7.3 Qualification on this JPM is required on a 3 year basis.
7.4 Personnel are to document their training using the Attachment 9.1 with its *Qualification Certificate* for this meter.

## 8.0 References

8.1 *Scott Scout* Personal Gas Monitor Installation/Operation/Maintenance Instruction

8.2 Gary O. Nelson, Gas Mixtures: Preparation and Control, Lewis Publishers, 1(992).

8.3 Gary O. Nelson, Controlled Test Atmospheres, Lawrence Radiation Laboratory, UC Livermore (1971).

## 9.0 Attachments

9.1 Qualification Criteria Record for SHSD personnel

9.2 Multiple Gas Meter Calibration & Maintenance Record

9.3 Multi-point Calibration Record.

9.4 Calibration Record for Multiple Point Calibrations

9.5 Calibration Standard Preparation Methods

| BROOKHAVEN NATIONAL LABORATORY<br>Safety & Health Services Division<br><br>**INDUSTRIAL HYGIENE GROUP**<br>Standard Operating Procedure | NUMBER<br>**IH75900**<br>REVISION<br>**Final Rev1** |
|---|---|
| SUBJECT:<br>**Calibration Method for Chemical Monitors/Meters** | DATE<br>**08/30/06**<br>PAGE<br>**5** OF 12 |

## 10.0 Documentation

| Document Development and Revision Control Tracking | | |
|---|---|---|
| Prepared By:<br>*(signature/date on file)*<br>R. Selvey 08/08/05<br>Certified Industrial Hygienist | Reviewed By / Date:<br>*(signature/date on file)*<br>Certified Industrial Hygienist | Approved By / Date:<br>*(signature/date on file)*<br>R. Selvey 08/12/05<br>Industrial Hygienist Group Leader |
| ESH Coordinator/ Date:<br>*none* | Work Coordinator/ Date:<br>*none* | SHSD Manager / Date<br>*none* |
| QA Representative / Date:<br>*none* | Training Coordinator / Date:<br>*none* | Filing Code:<br>**IH52.05** |
| Facility Support Rep. / Date:<br>*not applicable* | Environ. Compliance Rep. / Date:<br>*not applicable* | Effective Date:<br>**08/16/05** |
| ISM Review - Hazard Categorization<br>☐ High<br>☐ Moderate<br>☒ Low/Skill of the craft | Validation:<br>☐ Formal Walkthrough<br>☒ Desk Top Review<br>☐ SME Review<br>Name / Date: | IMPLEMENTATION:<br>Training Completed: To be conducted as needed<br>Procedure posted on Web: 08/30/06<br>Hard Copy files updated: 08/30/06 |

| Revision Log | | |
|---|---|---|
| Purpose: ☐ Temporary Change ☐ Change in Scope ☐ Periodic review ☒ Clarify/enhance procedural controls<br><br>Changed resulting from: ☐ Environmental impacts ☐ Federal, State and/or Local requirements ☐ Corrective/preventive actions to non-conformances ☒ none of the above<br><br>Section/page and Description of change: Added Job Risk Assessment to JPM form. Added Document/Record Control revision information to the two Attachment calibration forms. Added the forms to the SOP web page as stand alone attachments. | | |
| *R. Selvey 08/30/06(signature/date on file)*<br>SME Reviewer/Date: | Reviewer/Date: | Reviewer/Date: |

BROOKHAVEN NATIONAL LABORATORY

**IH75900 Attachment 9.1**
**HP-IHP-75900**

**Safety & Health Services Division**
**Industrial Hygiene Services**

# Meter/Monitor Calibrating Procedure Qualification Certificate

(Expires 3 years)

| Name | BNL Number: | Qualification Number: **HP-IHP-75900** |
|---|---|---|

| Topic | Criteria | Qualification Status | | |
|---|---|---|---|---|
| | | Not Qualified | Recov-ered | Satis-factory |
| **Sampling Equipment** | Can show where equipment needed for the procedure is located and how to properly sign it out and set it up. | | | |
| **Calibration Supplies** | Can show how to set up the calibration apparatus | | | |
| **Sampling Protocol** | Understands the logic necessary to appropriately select calibration points to accurately measure the meter response. | | | |
| **Meter Operation** | Can show how to correctly turn the meter on/off, warm-up, operate, and check readings with the meter.<br>• Turn the unit on & off<br>• Perform adequate warm-up of the unit<br>• Assemble the sample pump<br>• Simulate monitoring a test atmosphere | | | |
| **Set up of a known source** | Understands the principles, calculations and set up of source as per Attachment 9.4 | | | |
| **Stabilization of the meter and source** | Demonstrates knowledge in meter warm-up and the appropriate delay in accepting meter readings until the concentration is fully determined by the meter | | | |
| **Record forms** | Can show how to correctly and completely fill out all forms associated with this SOP.? | | | |
| **Record Retention** | Can show how to properly file records as the IH60200 requirements. | | | |
| **Risk Assessment** | Employee understands the risk and controls described in SHSD-JRA-03 IH Lab Work | | | |

**I agree to conduct work in compliance with the procedure**

| **Signature** | **Date** |
|---|---|

**Qualified by:**

| **Signature** | **Date** |
|---|---|

BROOKHAVEN NATIONAL LABORATORY

IH75900 Attachment 9.1

# HP-IHP-75900

IH75900 Attachment 9.2

# *Multi-gas Monitor*
# Calibration & Maintenance Record

| Customer Group: | Instrument Name: | |
|---|---|---|
| SHSD- IH-Group | *Scott Scout* | |
| Model: | Serial Number: | BNL# |
| *SCT* | 12345 | IHG54321 |

## Calibration Readings

| Calibration by: | Calibration date: | Next Due: |
|---|---|---|
| John Doe | 08/12/05 | 3 months |

| | Concentration | As Found | As Left | Pass/Fail |
|---|---|---|---|---|
| ☒ Oxygen (O2) | 20.9% | 20.9 % | 20.9 % | ☒Pass ☐Fail |
| ☒ LEL | 32% | 31 % | 32% | ☒Pass ☐Fail |
| ☒ Carbon Monoxide (CO) | 50 ppm | 15 ppm | n/a ppm | ☐Pass ☒Fail |
| ☒ Hydrogen Sulfide (H2S) | 25 ppm | 26 ppm | 25ppm | ☒Pass ☐Fail |
| ☐ Sulfur Dioxide (SO2) | | | ppm | ☐Pass ☐Fail |
| ☐ Nitrogen Dioxide (NO2) | | | ppm | ☐Pass ☐Fail |
| ☐ Nitrous Oxide (NO) | | | ppm | ☐Pass ☐Fail |
| ☐ | | | | ☐Pass ☐Fail |
| ☐ | | | | ☐Pass ☐Fail |

Sample

See SHSD SOP Web Page for a blank form

Problems During Calibration: The carbon monoxide sensor failed to record the correct value and could not be set to an appropriate level. Meter failed calibration on this sensor. A new sensor has been ordered from the supplier.

## Maintenance & Service Record

| | | | |
|---|---|---|---|
| Repairs:<br>Date:<br>By: | none where needed | | |
| New Sensors Replacement<br>Date:<br>By: | ☐ Oxygen (O2) | ☐ LEL | ☐ Carbon Monoxide |
| | ☐ Hydrogen Sulfide | ☐ Sulfur Dioxide | ☐ Nitrogen Dioxide |
| | ☐ Nitrous Oxide | ☐ Other: | |
| Battery Replacement:<br>Date: 8/12/05<br>By: John Doe | The battery was tested on a Volt-Ohm meter and found to be acceptable. The meters BAT indicator showed the battery level was acceptable. No changes were needed. | | |
| Comments: | None | | |

BROOKHAVEN NATIONAL LABORATORY

**IH75900 Attachment 9.1**
**HP-IHP-75900**

# *Multi-Point Calibration Record*

| Customer Group: | Instrument Name: | |
|---|---|---|
| Model: | Serial Number: | BNL# |

## Calibration Readings

| Calibration by: | | Calibration date: | Next Due: |
|---|---|---|---|
| Contaminant | Calculated/Known Concentration | As Found | As Left |
| Acetone | 500 ppm | 456 ppm | 500 ppm |
| | 100 ppm | 87 ppm | 99.5 ppm |
| | 50 ppm | 43 ppm | 50 ppm |
| | 10 ppm | 7 ppm | 10 ppm |
| | 1 ppm | None detected ~~ppm~~ | 1 ppm |
| --- | ~~ppm~~ | ~~ppm~~ | ~~ppm~~ |
| --- | | | ~~ppm~~ |
| --- | | | ~~ppm~~ |
| Recor | | | |
| Comments/ Problems During Calibration | | | |



## Maintenance & Service Record

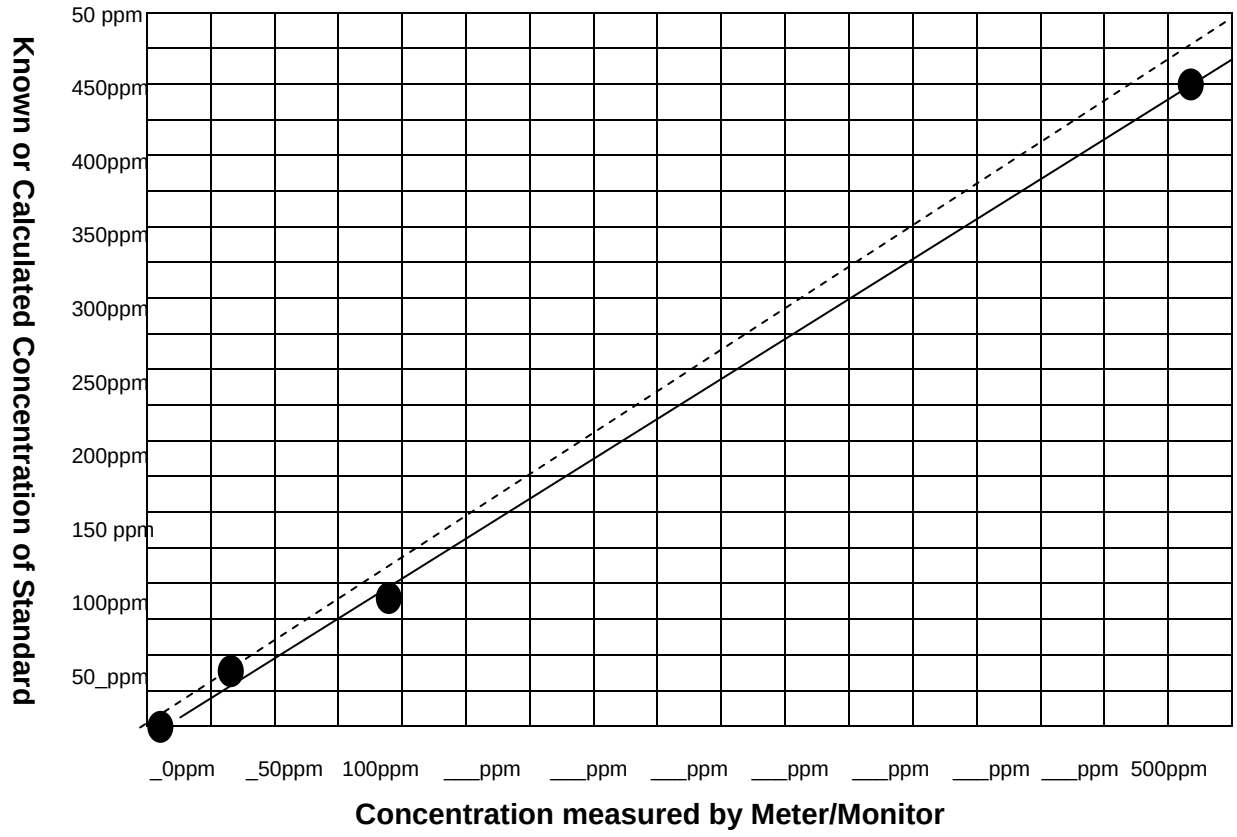
| | |
|---|---|
| Repairs:<br>Date:<br>By: | n/a |
| New Sensors Replacement<br>Date:<br>By: | n/a |
| Battery Replacement:<br>Date: 02/23/06<br>By: J. Doe | The battery was tested on a Volt-Ohm meter and found to be acceptable. The meters BAT indicator showed the battery level was acceptable. No changes were needed. |
| Comments: | |

## IH75900 Attachment 9.3

# *Multi-Point Calibration Record*



**Plot of Known to Measured Concentration**




**Details and Diagram of the Gas/Vapor Generation System**

***Diagram of System:***

***System Descriptions:***

# IH75900
# Attachment 9.4

# Calibration Standard Preparation Methods

**Principles:**
There are several methods for making accurate gas/vapor samples. The methods used at BNL are:

- Static bag mixture [used to TVA1000, and other small flow rate meters];
- Closed loop system [used for Miran Sapphire];
- Syringe pump injection into a flowing stream of air (dynamic) [rarely used- not described below. BNL owns a *Harvard Apparatus* Microliter Syringe Pump that can be used for this technique];
- Permeation tubes into a flowing stream of air (dynamic) [rarely used- not described below]. Permeation tubes are purchased tubes with a certificate of calibration containing volatile chemicals in tubes. The chemicals will permeate ("leak") through the walls of the tube at a rate that is controlled by the temperature. The permeation tube is placed in a temperature controlled glass chamber through which a controlled flowrate of the diluting gas is passed. The constant leakage of chemical into the constant flow of gas produces a constant concentration. BNL owns a MAST® apparatus for controlled heating and airflow though permeation tubes. The concentration can be varied by changing the flowrate of the carrier gas, or by changing the temperature of the chamber.

The methods for delivering known volumes of diluting air or nitrogen at BNL are:

- Gas syringes (i.e., Tracor Atlas cylinder) is used for bag mixtures. This 10 Liter syringe is filled to the mark from a second bag containing clean air or nitrogen, from a known clean air source, or from room air (drawn in through a charcoal filter if suspected to contain contaminants.)
- Air from a pressure pump or Compressed air cylinder with Stopwatch and flowmeter. The gas source is connected to a flowmeter and adjusted to the desired value. The total pump time needed to deliver the required volume of air is calculated. The flow is connected to the sample bag and the stopwatch is started. The flow rate is re-measured. At the end of this filling time, the bag is disconnected.

Tubing and gas sample bags must be compatible with the chemicals being handled. Compatibility involves three considerations:
**Reactivity: V**apor does not react chemically with the material. An example of an incompatibility is Ozone's reaction with many plastics and oils and processing chemicals from manufacturing.
**Permeation:** Vapor should not leak out through the material. Polyethylene, in particular, is permeable to many gases and in general should not be used.
**Absorption: T**he tubing or bag does not absorb the vapor from the sample.

## Method 1. Static Bag Mixture in a Tedlar® Bag:

The liquid is measured with a microliter syringe and injected into a sample bag. The bag is then inflated with a known volume of air. To calculate the correct amount of liquid to inject, you must know the molecular weight of the liquid, its density, the final volume of the dilution to be made, and the final concentration desired.

Applicability: This method can make from 1 liter to 40 liter of gas/vapor in air/nitrogen mixtures in the range of 1ppm to % mixtures. It is useful for calibration of monitors/meters that draw air in the cc/min to low liter/minute rate. Examples are the TVA-1000, Scott Scout, TLV Sniffer, H-Nu PID, and GasTech GC.

Equipment:

- 10 L Tedlar® Bag;
- 10 microliter gas tight syringe,
- Tubing (Teflon, silicone or Tygon®)
- 50-500 milliliter gas tight syringe
- Model 722K 10 L piston cylinder from *Houston Tracor Atlas, Inc*. or 500 cc syringe from *Precision Sampling Corp.* or Air from a pressure pump or Compressed air cylinder with Stopwatch and flowmeter.

For concentrations of 100 ppm or more, the Tedlar bag standard can be prepared at the desired concentration. For lower concentrations, make a 1000- 10,000 ppm stock sample in a 4-10 liter bag. Make dilutions for final concentrations from 0.1 -100 ppm by withdrawing known volumes of the stock, injecting it into a sample bag, and filling the bag with a known volume of dilution air.

The large-volume Tracor Atlas 722K syringe is useful for measuring <u>diluting</u> gases, but should <u>never</u> be used for contact with chemicals, for two reasons:
1.) The cylinder could become contaminated and
2.) The syringe uses a thin layer of silicone oil inside the barrel to aid plunger movement. Silicone oil will efficiently absorb many chemicals from the vapor phase, reducing the final concentration.

An alternative to using the Tracor cylinder is to use a calibrated sampling pump to deliver a known flow rate for a measured time period into the Tedlar bag.

The chemical should be introduced into the Tedlar bag via a syringe needle through the septum. It may be necessary to apply heat from a hair dryer, heat lamp or heat gun to volatilize the liquid within the bag. Do not overfill the bag. Mix the diluting air and the chemical gas or vapor within the bag by squeezing one end of the partially filled bag, then the opposite end, over and over in a “shifting, needing” action.

The formula to calculate the desired amount of chemical and dilution air is:

$$\text{ul of analyte} = \frac{\text{ppm desired} \times \text{mol. weight} \times \text{volume of air (liters)}}{24450 \times \text{liquid density at 20C (g/ml)}}$$

An example:
Preparation of a 5000 ppm Methylene Chloride in air bag standard:

mw = 84.9 density = 1.327 g/ml at 20C

$$\text{Microliters of MC} = \frac{5000 \text{ ppm} \times 84.9 \times 10 \text{ liters}}{24470 \times 1.327} = 131 \text{ ul}$$

## Method 2. Closed loop system

This method is used to calibrate instruments that have a fast air flow sampling that would consume Static bag mixtures before stable reading could be obtained. The Miran Sapphire at 14 liter/minute requires a closed loop calibration. In this system, a known amount of gas/liquid is injected into the septum of a diaphragm pump connected via Teflon® tubing to the inlet and outlet of the Sapphire. The internal volume of the Sapphire is 2.23 L. The internal volume of the pump is 0.01 L and the tubing is 0.002 L. Total volume of the closed loop is 2.242 L.

The formula to calculate the desired amount of chemical and dilution air is:

$$\text{ul of analyte} = \frac{\text{ppm desired} \times \text{mol. weight} \times 2.242 \text{ (liters)}}{24470 \times \text{liquid density at 20C (g/ml)}}$$

An example:

Prepare a 75 ppm Acetone in air bag standard:
mw = 58.08 density = 0.79 g/ml at 20C

$$\text{Microliters of Acetone} = \frac{75 \text{ ppm} \times 58.08 \times 2.242 \text{ liters}}{24470 \times 0.79} = 0.51 \text{ ul}$$